Allison (Jos. J.)

Observations relative to lymphatic hearts.

Robley Dunglison

1838

Contents

OBSERVATIONS

RELATIVE

TO

LYMPHATIC HEARTS.

BY JOSEPH J. ALLISON, M. D.

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OBSERVATIONS

RELATIVE TO LYMPHATIC HEARTS.

In 1832 Professor Müller of Berlin, discovered that the frog and some other reptiles of the orders Sauria and Batrachia,* are provided with organs, situated immediately under the skin, which exhibit distinct pulsations like the heart; and he ascribes to them the function of propelling the lymph towards the veins. The existence of these organs in the remaining orders, Chelonia and Ophidia, and in the *larvæ* of the Batrachia, was discovered by the author of the present paper in the summer of 1836; and a detailed account of them was presented that year in his Inaugural Essay.†

Müller denominates these organs *lymphatic hearts*, an objectionable term; inasmuch as the existence of a lymphatic system in reptiles, though generally admitted, is not absolutely proved. Thus Treviranus, among others, asserts that "all animals below the mam-

* Müller found the *lymphatic hearts* in the frog, toad, green lizard, and salamander. (Philos. Transact., 1833, p. 49. Poggend. Annal., 1832, Hft. viii. See also his Physiology translated by Baly, 1837, p. 275.) Professor Panizza of Pavia, has also published an Essay on the subject, entitled "*Sopra il Sistema linfatico dei rettili. Pav.* 1833, *fol.*" Not having seen this latter author's work, I am ignorant of the extent of his investigations; but he seems to have limited his inquiries to the animals in which lymphatic hearts had been discovered by Müller, as we would infer from the following passage in the Encyclopedia of Anatomy and Physiology, published in 1836. Under the head Amphibia, Mr. Bell says, "These lymphatic ventricles in the *amphibia* have still more recently received *further* examination and illustration from Prof. Panizza of Pavia, who published the result of his researches in 1833." The term Amphibia is here used as synonymous with the old order Batrachia, including frogs, salamanders, &c. Panizza has, however, found these organs in the *Coluber flavescens*; and Professor E. H. Weber has given an accurate description of the lymphatic hearts in a large species of serpent, the *Python bivitatus.* (See *Müller's Physiol. translated*, 1837, p. 275.) I saw a notice of the discovery two years after my own investigations were made.

† In several of the mammalia, namely, the dog, cat, mouse, and rat, I have discovered pulsations in the ischiadic region, probably analogous to the lymphatic organs in reptiles. The pulsation was not that of an *artery*; for in young kittens its frequency was *twice* that of the pulmonary heart. Farther examination however is necessary before I can decide with certainty upon the identity of the pulsations in question, with those in reptiles.

malia have no entire lymphatic system." Magendie* appears to entertain a similar view, and maintains with Spallanzani† that the appearance of lymphatics in reptiles is a deception resulting from the employment of refracted light, since the vessels in question belong to the sanguiferous system. The "Naturalist of Padua," did not, however, deny the existence of a lymphatic system in reptiles; on the contrary, he believed, that independently of the blood-vessels, the animal economy is provided with small canals which contain only a serous or mucous fluid, "*pourvue de canaux plus petits qui contiennent qu' un liquid sereux ou mucoux.*"

I am aware that Professor E. H. Weber of Leipsig, and Panizza, profess to have seen lymphatics in the larvæ of frogs. According to the former, they look at first view like a transparent border on each side of the veins; but the globules of blood are never seen to enter these borders, but from time to time, a round lymphatic globule passes along them, and which seems to move from $\frac{1}{10}$th to $\frac{1}{12}$th of the velocity of the blood—they vary from 0.003 to 0.00519 of a Parisian line. The transparent border referred to has been noticed before, and by Blainville attributed to the inner coat of the vessels being lined by a coat of serum. The same fact was observed by my preceptor, Dr. Darrach, in 1823.

Weber's views in relation to the transparent border referred to, are probably erroneous, since the existence of lymphatics in transparent tissues is often very difficult to prove; indeed Lippi is accused by Fohmann, Panizza, Rossi, Blandin, Cruveilhier, and others of having confounded lymphatics with veins in man; and it may be remarked that Breschet in speaking of the extreme minute ramifications of the

* *Mém. sur les vaisseaux lymphatiques des oiseaux*, Journ. de Physiol. Vol. I. p. 47. Magendie found *lacteals* ramifying upon the mesentery of a sea tortoise, the only reptile, I think, in which he could detect them.

What has been said in relation to the *lymphatics* does not apply to the *lacteals*, since not only have they been seen by Magendie, but by Hewson, Monroe, (the second,) Cruickshank, and Fohmann. Mr. Bell describes them as terminating in two thoracic ducts, &c.; and speaks also of the *lymphatic system* being developed to an extraordinary degree in the frog, as well as in some of the genera of this class; being found in numbers, and of considerable size, immediately under the skin."—(*Cyclopedia Anat. and Physiol.*, *Art. Amphibia*, 1836.)

Query? How are we to distinguish lymphatics in reptiles—they have no *glands* —and many veins are *colourless* when running through transparent tissues even in *man?* The *form of lymph globules* had not been discriminated, so as to serve for a test, when the supposed discoveries had been made.

† *Exp. Sur. La. Circulation. Diss. Seconde*, p. 280; and *Diss.* 1. Exp. XXVIII. LXVIII., LXIX., LXX.

central artery of the retina, says that there must exist veins which are colourless, and of such extreme tenuity that we shall in vain attempt to distinguish them from lymphatics. How much more difficult then to distinguish lymphatics in such an animal as the tadpole!

Since writing the above, I find my doubts in relation to the transparent border, strengthened by the observations of the translator of Müller's Physiology, who, in a note to that work, (p. 286,) states that M. Poiseuille—(*Ann. des Seienc. Nat.* Fevr., 1836, t. v. iii.) while watching the circulation in the capillaries, perceived that occasionally a globule of blood is thrown into the transparent space at the side of the current, and immediately loses its rapid motion; that it becomes quite stationary for a time if wholly without the current, while if only partly immersed in the transparent space, it is rolled along as it were by the blood moving rapidly over it. M. Poiseuille inferred from these observations, that there is in contact with the parietes of the vessels a layer of liquor sanguinis which does not move; and he states that M. Girard has demonstrated, that in case of inert tubes of small diameter, the portion of a fluid moving through them, which is in contact with their parietes, is stationary. The appearances above described have been observed by Prof. Weber, *and attributed by him, but less correctly, to the motion of lymph globules in lymphatics* surrounding the blood-vessels. The bodies which move thus slowly and irregularly along the sides of the current of blood are, for the most part at least, globular as he states, but they are *certainly within the blood-vessels;* they are evidently moved, as Poiseuille describes, by the same force that moves the current of blood, and are occasionally seen to re-enter this current.

Müller bases his doctrine of the *function* of the pulsating ventricles, on the fact, that we can inject the entire venous system from the organs in question. But we are not to infer from this circumstance that there is a connexion between the venous system and lymphatic organs, and such as he would imply, inasmuch as it is a well attested fact, that when a fine injection is thrown into the arteries of the belly it readily escapes from the internal substance of the intestines; when thrown into the vena portæ it returns not only by the veins and hepatic artery, but also through the excretory ducts; when thrown into the emulgent artery it soon passes into the emulgent vein —into the pelves of the kidneys and the ureter. Notwithstanding the above, we do not conclude, says Velpeau, that the blood during life is continually transuding into the alimentary canal, nor that it passes from the vessels of the liver into the hepatic ducts, or from the kidneys into the tubuli uriniferi and ureters. *The injections employed are of* *too penetrating a nature not to go wherever it may be desired to send them.*

Again, Magendie observed that when air was forced into the venous system of animals, the fluid passed from the pulmonary artery into the cellular tissue of the lungs, producing emphysema of these organs; and finally into the arteries of the body. In cases of artificial respiration, air is thus sometimes forced into the vascular system. In proof of this assertion, a case is related by Professor Jackson, in his lectures, of a man who died of hydrophobia, in whose arteries were found quantities of air; which fact is accounted for by Dr. J. from the powerful action of the respiratory muscles, at the time when the rima glottidis was spasmodically closed.

It has been maintained by Shultz and Broussais, (supported by observation,) that the capillary tissue is a cellular structure to which the arteries and veins perform the office of vasa afferentia, and vasa efferentia—and a somewhat similar view in relation to the vascular net-work character of this tissue, is entertained by Breschet, Cruveilhier and Mascagni, who maintain, however, that the vessels are *lymphatics* which form the tissue. This view seems to be supported by the microscopical observations of Professor Arnold of Zurich, and the injections of Fohmann in relation to the cellular tissue at the back of the eye. If either of these opinions be correct, we may readily account for the injection passing from the lymphatic hearts into the vascular system.

Our knowledge then being still vague in relation to the lymphatic ventricles, it would be better to call them the *anterior* or *scapular*, and *posterior* or *ischiadic pulsating organs.* The following descriptions of these organs are drawn up from observations made in numerous dissections.

Subcutaneous Sacs. (*Poches sous-cutanées* of Duges.) In the frog and other reptiles, the skin is not, as in most animals, a tight envelope. The lines of adhesion along the back, (one for either side,) commence at the ischiadic region, and pass forwards, diverging so as to form a boundary between the dorsum and flanks. At the head the adhesions are close and strong. The flanks have corresponding adhesions. The two orders of attachments give rise to a free space on either side of several lines in breadth; constituting a subcutaneous sac, termed by Duges the *lateral.* There are attachments of another character between the muscles and integuments; viz: capillaries, which are especially numerous about the hinge-like process constituting the pelvis. These vessels, in general, pass obliquely outwards and backwards from the depressed raphé of the back to the integuments, so as to allow considerable looseness to the skin. Many of these capillaries being colourless, doubtless owing to refracted light, have probably been mistaken for lymphatics.

In the frog there are numerous subcutaneous sacs, which have been delineated by M. Duges;* and according to him are in all twenty-two in number. Of these, four are symmetrical, namely,—the dorso-cranienne, sous-maxillaire, thoracique and abdomino-sus-palmaire. Those in pairs are,—the lateral, iliaque, brachiale, femoral, susfemoral, interfemoral, jambiere, sus-plantaire, and plantaire.

The subcutaneous sacs are of two kinds—a distinction omitted by our author. The one containing lymph, (*lymphraüme* of Müller,) the other an æriform fluid; the latter, it is probable, furnished the gas obtained by Edwards, when frogs were caused to respire in hydrogen. The volume of gas thus procured, is said to have equalled the animal's bulk in a very short time; and could the *entire* bulk have been exhaled from the blood? Cutaneous sacs exist in the tadpole, and in all those animals in which the lymphatic hearts are found, the same general arrangement prevails.

Subcutaneous Fluid.—Müller views the subcutaneous fluid as identical with lymph; but it has not been analysed. He alludes to its coagulability—and this only. Until better acquainted with its office, I shall name this the *subcutaneous fluid*, not to add to the ambiguity in relation to the term lymph. According to Brande's analysis, the subcutaneous fluid must be viewed as a distinct fluid, as it contains a notable portion of albumen, while lymph has so little as not to coagulate except by galvanism. The former has a decided alkaline reaction, which the latter has not. On the contrary, according to M. Raspail's analysis, the analogy is more close.

The subcutaneous fluid may be obtained in considerable quantity. At first it presents the appearance of an aqueous fluid, which soon becomes viscous, and finally coagulates. It separates into a coagulum and serum. The former is jelly-like, and nearly colourless. The taste of lymph is slightly saline, and restores colour to reddened litmus, a circumstance, however, which does not imply that a *free* alkali exists, for, according to Dr. Stephens, the supercarbonated alkalies as they exist in the blood, have the above effect, at the same time acting as salts in giving to blood its arterial hue.

A quantity of the subcutaneous fluid having been received into a watch glass, was examined with the microscope. In about five minutes crystals were noticed forming rapidly across the mass, no corresponding motion, however, being observable among the globules themselves;

* *Recherches sur L'Osteologie et Myologie du Batraciens, a leur differences ages, &c.* Avec 20 planchas. Par Ant. Duges, Prof. a la Faculté de Médecin de Montpellier, &c. 1835. Paris.

but as the crystallization shot forwards, the globules of the fluid became separately a new centre of crystallization, forming altogether a beautiful appearance. These crystals resemble those of the hydrochlorate of ammonia, depicted in Raspail's Organic Chemistry. (Plate VI., fig. 12.) They have been detected in the saliva before eating—in urine, and in the serum of the blood. These crystals bear no resemblance to those represented by Sir E. Home, (Comp. Anat., Vol. VI., p. 8,) which were found deposited in the coagulable lymph of an aneurismal tumour, since the latter approached the rhomboidal form, &c.

The subcutaneous fluid exhibits under the microscope innumerable particles, which Müller has not noticed, and of no uniform size; in this respect resembling those of the blood; for according to Milne Edwards, the blood globules of the *Rana temporia* vary from $\frac{1}{114}$th to $\frac{1}{140}$th of a line in diameter. They may be seen by a lens of very moderate power. These particles are not those of air—there is a peculiar *hyaline* aspect in the one, which the other has not; a circumstance by which the practised eye can never be deceived. Air bubbles moreover seldom assume the regular *elliptical* form; other points of resemblance may indeed be sufficiently striking to deceive the most experienced eye. We see here and there in the midst of the clot, patches of serum, the particles of which have a free motion among themselves; a fact which supports the opinion advanced by Berzelius and substantiated by Müller, that the coagulation of the blood results from the fibrin dissolved in the serum, and is wholly independent of its globules; a theory opposed to that entertained by Home, Prevost and Dumas, and others. Between the particles of the coagulum and those of the serum, no sensible difference could be discovered. The globules of the subcutaneous fluid have a tendency to collect into clusters; but I have not detected any arborescent arrangement, as has been affirmed to take place in the blood of reptiles and that of man. It is true we can cause a sort of mesh-work, when the lymph is placed between slips of glass, as recommended by Lister and Hodgkin; but a similar appearance forms in water under like circumstances; the appearance being wholly unlike that of the blood.*

* Müller in his *Physiology*, which we have seen since the preceding observations were made, gives more definite information respecting the lymph. He observes that by drying the fibrinous coagulum of a known quantity of lymph, and then weighing it, eighty-one parts of frog's lymph contain one part of dry fibrine, a proportion which seems remarkably large. If frogs are kept for a long time, their lymph ceases to be coagulable; the same is more or less true of the blood.

He speaks also of the globules, which he says are one-fourth the size of those

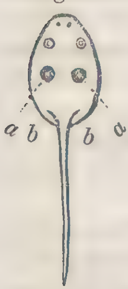
The author has studied, with some attention, the structure of these globules, but as the accuracy of his observations require to be further tested, he defers publishing his researches till a future period, when he will offer a theory as to the nature of the fluid itself, illustrating the capability of the animal economy of resisting those external influences, which would otherwise prove its destruction.

Pulsating Organs in the Larvæ of the Frog.—These become visible in the tadpole about the period when the external branchiæ appear; they lie immediately under the skin, on either side of the dorsal line of the body.

Fig. 1.

The following figure (1) represents these organs in a tadpole immediately after the absorption of the external branchial apparatus; the anterior *a*, and posterior *b*, seem continuous, which renders it difficult to appreciate their respective motions, but the distinction becomes obvious as the animal grows.

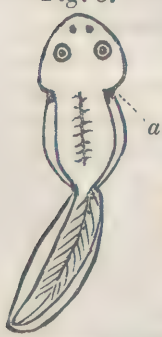
Fig. 2.



The distinction between the two sets of organs is well seen in a tadpole of the size represented by the accompanying figure (2), of which *a* are the anterior and *b* the posterior organs.

The following cut (*fig.* 3) represents the *anterior* organs in a larva advanced in its developement, the legs being about to appear. After skinning the animal, we see behind the transverse process of the third cervical vertebra, at the point *a*, a black diaphanous space, which pulsates regularly.

Fig. 3.



The *posterior* pulsating organs are situated along the caudal vein, and generally at those points where the four or five anterior branches are received. Their general appearance is that of gelatinous bubbles, probably cellular substance in the amorphous state of Meckel, and not assuming the type of that tissue till the animal is fully developed. This fact supports Tiedemann's assertion, that cellular tissue possesses a contractile power differing from elasticity.

The following figures exhibit the posterior organs in tadpoles during their different stages of develope-

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of the blood, and are round and not flattened; thus differing from those of the blood.

Müller's observations likewise confirm our remark in relation to the globules of the lymph having no share in the coagulation. (*Müller's Physiology*, 1837.)

ment, showing that as the tail disappears the relative space occupied by the pulsations becomes proportionately lessened.

Fig. 4, represents a full grown larva of the *Rana pipiens,* the hinder legs of which have just protruded.

Fig. 4.

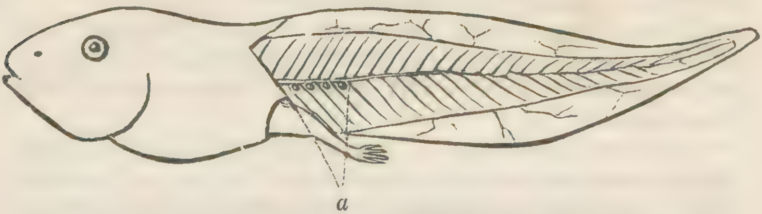
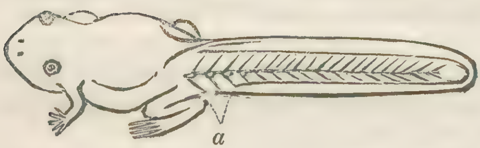


Fig. 5.



In the opposite specimen (*fig.* 5) all four legs are out, the lungs are considerably advanced towards their function, being partly tubulated, and partly cellulated.

Fig. 6.

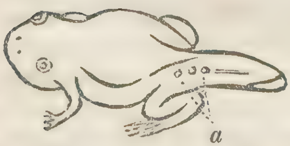


Fig. 6, represents a tadpole, the tail of which is nearly gone.

In all the above figures, letter *a* refers to the posterior pulsating organs.

Fig. 7.*

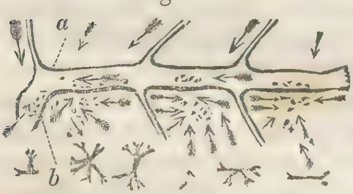


Fig. 7 is intended to represent the motion communicated by the pulsations to the *maculæ* scattered throughout their substance; showing, in fact, their *own* motion. *a*, Caudal vein; *b*, situation of the pulsations, being mostly *below* the vessel. The pulsations give rise to corresponding *locomotion* of the branches sent off from the caudal vein, and frequently to the main trunk itself, which is represented in the cut by *featherless* arrows.

The pulsating organs present *black maculæ,* which, as they recede from the organs in question, become more and more scattered; and it is by their presence that we are enabled to study the motions of the pulsations, which, from their transparency, would have been difficult. During the *dilatation* of the hearts, these maculæ rush from a circum-

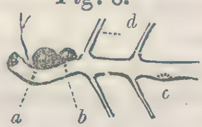
* Figs. 7 and 8 are magnified views.

ference towards the centre, and the light is simultaneously reflected as by a bubble of air. These motions are exhibited by Fig. 7, which also shows a magnified view of some of these maculæ.

When viewed in the direction of the animal's length, the lymphatic ventricles become prominent during each dilatation, and when viewed in a certain light a depression will be noticed to follow the contraction. The pulsations are not always synchronous with those of the same pair, nor with the opposite pair; this is seen in Fig. 8, for when *a* contracted *b* dilated.

The pulsation of the caudal *vein* I noticed but once, although sought for with different lights and powers, and in one specimen for two hours; the contraction is represented in the accompanying figure by the dotted semicircle at *c*.* Hence, it must be evident that the *pulsations of the lymphatic organs are not dependent upon those of the caudal vessel.*†

Fig. 8.



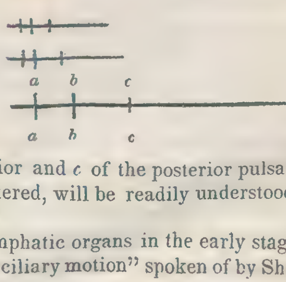
Anterior pulsations in the Frog.—Marshall Hall, in his Essay on the Blood, describes a vessel of the frog which pulsates independently of the heart, and brings forward this fact as proof of arterial contractility. Professor Müller proves the supposed artery to be a vein, and its action to depend, not upon an irritability of its own, but on that of the adjacent cellular tissue. He views the pulsation as produced by a distinct organ, which he calls the "*anterior lymphatic heart.*"

The anterior pulsating organs are two in number, one for either side, and are situated beneath the posterior angle of the scapula at

* There was extravasated blood in the pulsations which diminished in bulk simultaneously with the contraction. The curve of the vessel would become nearly straight during the continuance of the pulsation, and locomotion communicated at the same time to the branch *d*.

† The following figures are intended to represent the relative position which the lymphatic organs assume in different stages of the tadpole's growth. The horizontal line exhibits the entire length of the tadpole, while *a* represent the situation of the eyes, *b* of the anterior and *c* of the posterior pulsating organs. The figures 1 and 2, though not lettered, will be readily understood by comparing them with figure 3.

Fig. 1
Fig. 2
Fig. 3



I should have stated elsewhere that the lymphatic organs in the early stage of the tadpole must not be confounded with the "ciliary motion" spoken of by Sharpless and others.

the extremity of the transverse process of the third cervical vertebra. Each "heart" consists of two portions, the posterior of which is the greater and of a triangular form.

To obtain a good view of the anterior pulsating organs, it is necessary to expose the abdominal cavity, and reflect back the triangular membrane, which lies over and obscures its motion; several layers of cellular tissue bound firmly over the heart may also be dissected off. The pulsations then become very distinct. Another view may be obtained by reflecting the skin from the back, and cutting away a portion of the scapula, which Müller considers the better view. In the toad the anterior hearts are remarkably distinct, and in order to obtain a dorsal view of them the scapula need not be removed.

Hall describes the vessel emerging from the scapular pulsations as a branch of each of the arteries, which, after separating a short distance from the pulmonary heart, rejoin, and form the aorta. A favourite theory has evidently misled our author. The vessel, in fact, which proceeds forwards from the organ parallel to the vertebral column, is a vein, which unites with another from the occiput; the small trunk produced by this union, namely, the jugular vein, now descends, receives branches from the scapula and axilla, and finally from the region of the throat, then ends in the vena cava superior, at the place where the great veins of the arm enter the latter.

In order to observe to advantage the supposed artery of Dr. Hall, we must dissect away the tissues exterior to the vessel; a good view may also be obtained from the back by cutting off a portion of the scapula. The blood in the trunk and auxiliary branches will be found to oscillate at each dilatation of the organ, and then resume the venous current; simultaneously with the dilatation, the vessel in question is drawn towards the organ itself with considerable force, becoming at the same time *contracted* and *pale*. Marshall Hall, then, is correct when he asserts this fact, but his inference is erroneous. He views the contractions as that of an artery resulting from an inherent contractile power; whereas it arises from tension of the vein, exerted by an exterior force. The same remarks apply with equal force to Müller's views. He conceives the vessel to dilate simultaneously with the contractions of the lymphatic organs. True, but the dilatation depends upon the tension being removed which had contracted the vessel, and not from distension of fluid *forced* into the vein from the lymphatic heart, as he would imply.

In order to destroy the function of the anterior organ it may become necessary to dissect away many layers of cellular tissue, when the locomotion of the vessel itself will also generally cease. The neglect of this precaution may in part account for Dr. Hall's error in asserting that the vessel will be seen plainly to pulsate after the destruction of the above mentioned tissue. It is possible, however, that the vessel may have pulsated independently of the lymphatic and pulmonary organs, inasmuch as certain veins possess in themselves an inherent contractile power, as I shall endeavour to establish in a future paper.

By making an incision into the anterior pulsating organ, we can inject air or mercury into the subcutaneous sacs of the axilla, thence into the vena jugularis, vena cava superior, auricle, ventricle, and finally into the arterial system; the pulsating organs will still continue their function.

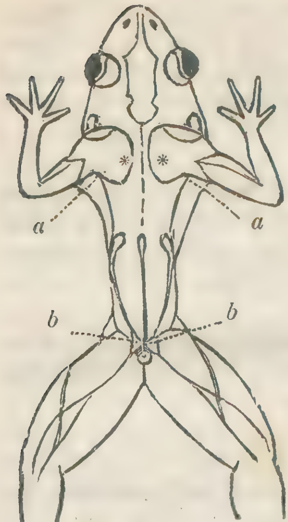
According to Müller, the anterior lymphatic hearts receive the lymph from the anterior portion of the body, and probably also from the intestinal canal, in order to send into the jugular vein.* This assertion I have not verified, not having been able to detect the actual flow of lymph into the venous system, from either the anterior or posterior pulsating organs. It is proper to remark, however, that having on one occasion pressed my finger upon the anterior heart, that I noticed globules of a fluid to enter the vessel in question, and distend it very much. The lymphatic sac immediately anterior to the organ, became likewise turgid. The distension of the vein, however, probably resulted from accumulation of fluid, from the pressure necessarily exerted upon the neighbouring vessels.

Posterior Pulsating Organs in the Frog.—These were discovered by Müller. They are situated in the ischiadic region, and lie immediately under the skin. When we remove the integuments, which is generally unnecessary in order to detect them, there are noticed two blackish triangular-like depressions in the region indicated, one on either side, which have distinct pulsations averaging about 80 per minute.† In the *Rana fontinalis* their length, parallel to the axis of

* Müller, estimating the capacity of each of the lymphatic hearts at one cubic line, calculates that the quantity of lymph which they would project into the veins in a minute, supposing that they empty themselves entirely at each contraction, would be $4\times60=240$ cubic lines, since they contract about sixty times per minute. But they expel only a part of their contents at each contraction.—*Elements of Physiology, translated by Baly.*—p. 286.

† *Muscular spasms, &c.* are apt to deceive, being often mistaken by the inexperienced observer for the pulsations themselves. When we seek for the pulsations in the tadpole through the microscope, the motion of the eyelids is a frequent source of deception, for the least motion being reflected from the glass, seems like a pulsation in the animal itself.

Fig. 9.



the body, is about two lines, and their breadth one line and a half. The ischiadic artery and vein, accompanied by the crural nerve, in their exit from the pelvis, pass beneath the outer margin of these organs.

The accompanying figure (9) represents the lymphatic hearts in the *Rana halecina; a,* position of the anterior pulsating organ (dorsal view); *b*, the posterior pulsating organ bounded anteriorly by the coccygeal muscle, which is seen in the figure just above the cloaca.

When the ischiadic organs contract, motion is communicated simultaneously to the coccygeal muscles and tissues adjacent, and we often see a perceptible locomotion of the vessels of the thigh as they pass through the organ.

Fig. 10.

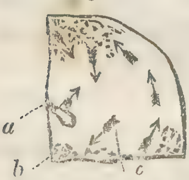


Fig. 10 presents an enlarged view of the posterior organ of the left side. The arrows indicate the irregular dilatation which is rendered evident in the animal itself, by the presence of black maculæ, scattered here and there through the tissue. The posterior outer angle *b*, elevated itself with each contraction, and the internal structure of the organ separated into globular portions not unlike the rudimental pulsations as they exist in the larvæ. In the specimen from which the drawing was taken, a bubble as of air was noticed at the point *c*, which had a motion corresponding to that indicated by the arrow. Simultaneously with the dilatation of the organ, a brownish-red fluid was also noticed, which disappeared with the contractions—a circumstance not uncommon.

We may obtain a posterior view of the organs from the abdominal cavity; and when the pelvic or hinge-like bone is elevated, it becomes evident that the corresponding hearts are separated from each other by the interposed rectum.

The maculæ of the pulsating organs consist of two distinct portions; the pigment, properly so called, and numerous gritty-like granules enveloped in a cellular capsule. These granules present under the microscope an opaline appearance, and seem to be made up of others, which give to their surface a studded botryoidal appearance.

The pulsations of the organs do not depend upon the superficial cellular tissue, for this may be removed, together with the black granules constituting the maculæ, so as to leave a line in depth, without the function of the organ being necessarily destroyed; (in one specimen, when the last layer of the tissue had been dissected off, colourless globules, suspended in a fluid, passed out in a vortex.) Neither does the pulsation depend upon the ischiadic vessels, since the latter, were it ever so great, would be inadequate, inasmuch as it is one, sui generis—the pulsations continuing when the vessels and pulmonary heart are destroyed. A fact better demonstrated in the tadpole.

Anteriorly to the lymphatic hearts there is on either side a subcutaneous sac termed by Duges *iliac*, containing a fluid often mixed up with a gas. Pressure on this sac renders the pulsating organs turgid, the fluids accumulating within, and this condition ceases on the removal of the pressure. The distension of the organ does not destroy its function.

The fluid in this sac frequently oscillates, owing to an impulse from the lymphatic heart, the oscillation being greater in its vicinity. In order to notice this oscillation, the bubbles of the fluid must be continuous, since if they be isolated by pressure, the motion cannot be communicated from the fluid in the organ to that in the sac, a circumstance which favours the idea of a direct communication between them, which I think I have seen in my dissections. The fluid in the sac could not have been put into motion from mere contiguity of tissue. When the sacs are distended, and the pressure removed, the fluid escapes through the medium of the organs into the adjoining sacs.

We often see bubbles of gas in the vessels, in the immediate vicinity of the lymphatic organs in the frog, tortoise and other reptiles. I have also detected a *free gas* circulating in the blood-vessels of several of the mammalia, both in arteries and veins.

The inflation of the posterior pulsating organs fills a lymphatic sac lying under the skin at the posterior extremity of the abdomen; another between the abdominal muscles and peritoneum, in the same situation on either side. Müller affirms that a large lymphatic vessel with thin coats becomes filled, leading in an upper direction to the arteria iliaca, and appears to come in contact with that of the opposite side, ascends towards the aorta abdominis like the ductus thoracis, but the vein cannot be further inflated in an upward direction, and thinks that it is possible that lymph of the posterior of the abdomen goes to the posterior lymphatic hearts, while the lymph of the intestinal canal and anterior of the abdomen goes to the anterior lymphatic hearts.

If the lymphatic organ be further inflated in an upward direction of the animal, a superficial vessel becomes filled, which proceeds from the back into the organ. The inflation of the posterior heart fills the abdominal sacs generally. We can also inflate the spaces of the thighs, and sometimes those of the legs to the extremity of the toes; several ounces of mercury can thus be forced into a small frog, and by using the coarse injection a pretty preparation of the different subcutaneous spaces may be obtained. The lymph sacs of the ischiadic region, and those of the thigh communicate, inasmuch as we can inject the one set from the other.

The connection of the posterior lymphatic organs with the venous system merit attention. The veins of the hinder extremities are the vena cruralis and the vena ischiadica, these unite above the thigh by a large transverse anastomosis. The vena iliaca is the continuation of the vena ischiadica; these become the venæ renales advehentes Jacobsoni, which pass into the kidneys after receiving branches from the posterior region of the abdomen. The transverse anastomosis of the vena cruralis and vena ischiadica passes in the regio pubis into the vena abdominis anterior impar, so that both cross veins unite in a semicircle, from the middle convexity of which the vena abdominis anterior springs, while the extremities of the semicircle pass behind into the vena ischiadica. The vena abdominis anterior, receives the blood of the abdominal muscles, and, as happens in all amphibia, passes to the vena portæ of the liver.* Thus the blood of the posterior of the body, says Müller, does not immediately reach the vena cava inferior, but, according to Jacobson, first passes through the vena advehens of the liver and the venæ advehentes of the kidneys. The venæ advehentes of the kidneys, and the vena advehens anterior cum vena portæ become filled with air each time the lymphatic hearts of the regio ischiadica is inflated, while the air passes into the vena ischiadica which lies under the lymphatic heart through the venous branch, and then passes further, partly through the venous semicircle into the venæ renalis, and veins of this side, partly through the venous semicircle into the venæ renalis advehentes of the other side, and into the venæ abdominis anterior;† thus from either organ we can inject

* Venous system cited by Müller from Jacobson in Meckel Archiv. für Physiologie, 1817.—p. 147.

† In the amphibia, as in the mammifera and birds, there is found a vena portal system, only much more extensive, since, from the researches of Bojanus, (Ad-

the extreme branches of the toes, the mesentery, liver, kidneys, œsophagus, &c.

Pulsating Organs in the Sauria.—Their relative situation is the same as in the salamander and larvæ of the frog; but in the *Tropidolepis undulatus,* it is difficult to find the posterior organs, since they are concealed by muscles. Müller found the organs in the *green lizard,* and he says it is only necessary to skin the animal in order to detect them; hence the facility of distinguishing the pulsations must be greater in some of the Sauria than in others.

Fig. 11 represents the *Tropidolepis undulatus; a* indicates the situation of the posterior organ.

Fig. 11.

Pulsating Organs in the Ophidia.—I found it difficult to discover these organs in the snake, owing to the oscillations into which its numerous muscles are thrown when it is skinned. I eventually succeeded, however, by taking advantage of the fact, that water of a certain temperature destroys muscular irritability in the frog, while the functions of the pulmonary heart are not sensibly affected. A snake (*Coluber sirtalis*) was immersed in water at 120° F., convulsions soon followed, and the animal became permanently rigid; the animal being skinned, the pulsations were readily detected above the cloaca, and presented a cellular appearance of several lines in length. A very good view may also be obtained from the abdominal cavity as in the frog. The pulsations are partly concealed by muscles.

After having once seen the pulsations of the lymphatic organs in the snake, they may be readily distinguished from muscular oscillations.

In the snake the subcutaneous fluid is not so great in proportion as in the frog and toad.

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versar Anat. Vol. V., p. 24), not only the veins of the stomach, the intestinal canal, the spleen and pancreas, but moreover, those of the posterior extremities and integuments of the belly contribute in forming the vena portæ.

Fig. 12.

a

Pulsating Organs in the Chelonia.—I discovered the lymphatic organs in the *Cistuda clausa.* In order to obtain a view of the posterior pulsations in this animal, take off the hinder hinge of the plastron, and then skin the thigh till the cellular tissue is fully exposed; this is to be carefully separated from its connections with the carapace, or upper shell, when the pulsations will be found in the ischiadic region, being remarkably distinct and strong. The posterior organs are seen in the annexed cut, *fig.* 12, *a.*

The following table exhibits the frequency of the lymphatic organs in seventeen individuals, compared, in some instances, with the pulmonary heart and respiration, in which case they were counted immediately after each other, the time thus occupied being about five minutes for each specimen. The *lymphatic hearts* were counted *before* the knife was resorted to.

Lymphatic Hearts.	*Throat.*	*Pulmonary Heart.*	
100.80.64	120*		
58.			
120.		160.†	
160.		120.	*In Frogs.*
100.68.		100.68.	
60.56.	105		

* It is generally thought that cold-blooded animals breathe slowly. In proof of this, Dr. Stevens affirms, that a young alligator, though agitated from having been laid hold of, breathed from three to four times in a minute. (Stevens on the Blood, p. 35.) This by no means holds good in relation to the frog, since their respirations are more frequent than in man: respiration in the latter being, on an average, from 14 to 27 per minute.

† Whytt makes pulsations of the pulmonary heart, when exposed, about 65 per minute. Spallanzani and Dr. Edwards, I think, make the same average, and Fontana nearly the same.

160.80.	50.60.		
120.80.	60.		
160.120.			
80.			
120.80.68	130.120		
100.80.		48.40.60.	*In tadpoles.*
100.		120.	
200.		120.	
160.			
200.			
160.88.		140.100.92.96	

From the preceding table we may draw, among other inferences, the following:

First. That the pulsations of the lymphatic organs vary in different specimens from 60 or less to 200 per minute.

Secondly. That they vary in the same individual so as sometimes to double themselves in frequency.

Thirdly. That the lymphatic pulsations bear no fixed relation to those of the pulmonary heart, or to respiration, the lymphatic hearts being on an average of a greater frequency.

At a future period I shall offer a summary of experiments relative to the connection which subsists between the functions of the pulsating organs with the circulation and respiration.*

* Since the present paper was in type, I discovered (July 4th) the lymphatic hearts in FISHES; viz. in the sunfish, catfish, perch, &c. They were seen by Professors Jæger and Henry, of Princeton College, and by Mr. William Rogers, of that institution, who assisted me in my experiments. My investigations relative to the LYMPHATIC HEARTS IN FISHES will shortly be published.